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BY SIMON WATERS

CENTRAL FORECASTING DIVISION

MAY 1994

TECH NOTE CF 19

Headquarters, Bracknell

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Central Forecasting Division.
Meteorological Office,
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Bracknell, Berkshire.
RG12 2SZ

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Subjective Assessment of Ambiguity Removal Confidence for ERS-1 Scatterometer Winds.

Introduction.

The UK Meteorological Office performs its own derivation of 10 m winds from the ERS-1 Scatterometer [1]. As part of this process of deriving these winds an 'Ambiguity Removal Confidence' is calculated. The resultant data is stored in the 'Meteorological database' from which it is retrieved and used in the assimilation process of the operational forecast suite.

As part of the derivation of wind speed and direction several 'solutions', with varying wind directions, may be generated. An empirically based confidence (The Ambiguity Removal Confidence, hence forth referred to as 'ARC') that the preferred solution has correctly been chosen is calculated. The purpose of this note is to present the results of a subjective study into the skill of the ARC parameter, with a view to excluding data failing to reach a certain threshold of confidence.

Design of Study.

The study was in three parts.

1) Examining a case queried by CFO from examining hemispheric surface charts with ERS-1 winds plotted on them.

2) Selecting data where the direction is more than 40 degrees different from the background used in the Ambiguity Removal process, and trying to classify various individual observations as good or bad, based on the synoptic situation as portrayed by the background field, and the internal consistency of the swath.

3) Examination of further cases to see whether there is support for the preliminary conclusions from part 2.

1) Investigation of CFO case.

CFO queried the Scatterometer winds for the 12Z global runs on the 11 September 1993. On one swath of data in the South Pacific, two areas of poor data could be identified (one area at 20S 162W, the other near 35S 155W).

Both areas of bad data are due to problems with Ambiguity removal. Both are on the near side of the swath to the satellite. Both areas contain observations with high ARC values (including the maximum ARC value 100), implying a high level of confidence that the solutions are correct.

It is difficult to identify the cause of the problems in these areas. It seems surprising that the ARC should be so high, this is presumably because alternative solutions were worse.

Since both areas of concern are on the same satellite pass, and that similar extreme cases of failure of the Ambiguity removal scheme have not been noted, it seems plausible that the instrument may have been malfunctioning in some unusual fashion (occasionally we receive faxes from ESA detailing satellite orbit and other problems after the event, although none were received in CF5 for this orbit).

2) ARC where Observed and Forecast Directions differ by 40 degrees

Over a number of separate days, cases where the difference in direction between derived and background exceeded 40 degrees were selected (Subjectively). Chiefly areas where several observations differed were selected. Within the selected areas, one or two individual cells (Observations) were selected for detailed examination. An assessment of the synoptic situation based on the background field, and other information if available, was made, and then the swath was examined for self consistency, and whether it reflected the synoptic situation. Attention was only paid to cells that had no flags raised which would exclude them from the assimilation scheme, (e.g. the Scatterometer had to be fully operational, with all three beams operating, no noise or arcing flags raised, and the retrieved wind had to be between 4 and 24 ms^{-1}, and that the cell was not on the inner edge of the swath). Cells were then classified as either good, bad or questionable.

Of the observations selected for consideration, the majority were classified as good. The previous statement implies that the forecast (background) field was in error by 40 degrees, however, in most cases interesting synoptic features could be identified (e.g. troughs, cyclones, anticyclones) and these were differently placed between the model and the observations, or the features (particularly troughs) were better defined in the Scatterometer swath, presumably as a result of resolution.

Areas of wide-spread, fairly even flow, containing areas differing from the model, were hard to classify, and cells in such areas were generally marked good if they were consistent with the rest of the swath.

The ARC value of all the cells selected were then recorded and the results tabulated in table 1.

Table 1. Results of Subjective Assessment of Scatterometer data.

	Classification				
ARC	**Good**	**Bad**	**Questionable**	**Total**	**Percentage good**
100	8	1	1	10	80
90-<100	19	3	2	24	79
80-<90	5	3	3	11	45
70-<80	4	2	1	7	57
60-<70	2	5	1	8	25
50-<60	1		3	4	25
00-<50	1		1	2	50

It was noted that areas of bad data were often associated with the inner edge of the swath, where it has long been known that the inner-most observations are of poorer quality. Indeed the innermost row of cells in the swath are permanently rejected from the assimilation. The third stage of the wind derivation process, the *Autonomous Ambiguity Removal* scheme is designed to *tidy-up* the swath and appears on occasion to propagate a region of poor ambiguity on the inner edge further across the swath.

3) Further Case of Interest

Case 1. Pass over tropical cyclone Emily (15:12 UTC 30 August 1993)

This case is typical of other passes over other deep tropical depressions. The swath showed a well-defined centre to the depression. No problems with the ambiguity removal were seen, and the confidences were high. However the case is a good illustration of resolution differences between the model and the Scatterometer.

In the swath maximum winds are seen at the centre of the cyclone of 40 knots. The maximum winds in the model are seen 2 to 3 degrees from the centre and are typically 20 knots. The maximum sustained winds from Tropical Cyclone advisories were 75 knots. The Scatterometer observations are probably lower due to problems in representation (the maximum sustained wind is sustained for only one minute), and of instrumentation and derivation (the radar was designed to work in the range 4 to 24 ms^{-1}, and assumptions are made in deriving a '10 metre wind' which are violated in such extreme conditions).

Bi-linear interpolation to the observation position from the model grid means that the current observation processing system has large vector errors for these observations, this results in the data failing the background check. As the information contained is beyond the current resolution of the model this is probably beneficial to the assimilation, although it unfairly implies that the observations are 'wrong'.

Case 2 Pass Over Tropical Depression at 20S 160E (23:17 UTC 25 November 1993)

This case, involving a pass directly over a tropical depression, was picked up by the intervention forecaster from the hemispheric plots of Scatterometer winds. Both the ESA and UK MO derived winds fail to resolve the feature properly due to failing to select the correct solutions, however they fail in different regions.

The UK MO derived swath had an area where the reciprocal solution was chosen to the South of the low, in an area of 30 knot wind speeds. This results in an unrealistic line of convergence where this area borders the area further south, where the correct solution was chosen. It seems to the author that such a line of convergence in a Scatterometer product should be identifiable with an automatic QC scheme, and would nearly always indicate an error in the ambiguity removal. It is of course possible that the area of incorrect winds might span the boundaries of two or more Scatterometer products, in which case removing one product would not remove all the associated bad data.

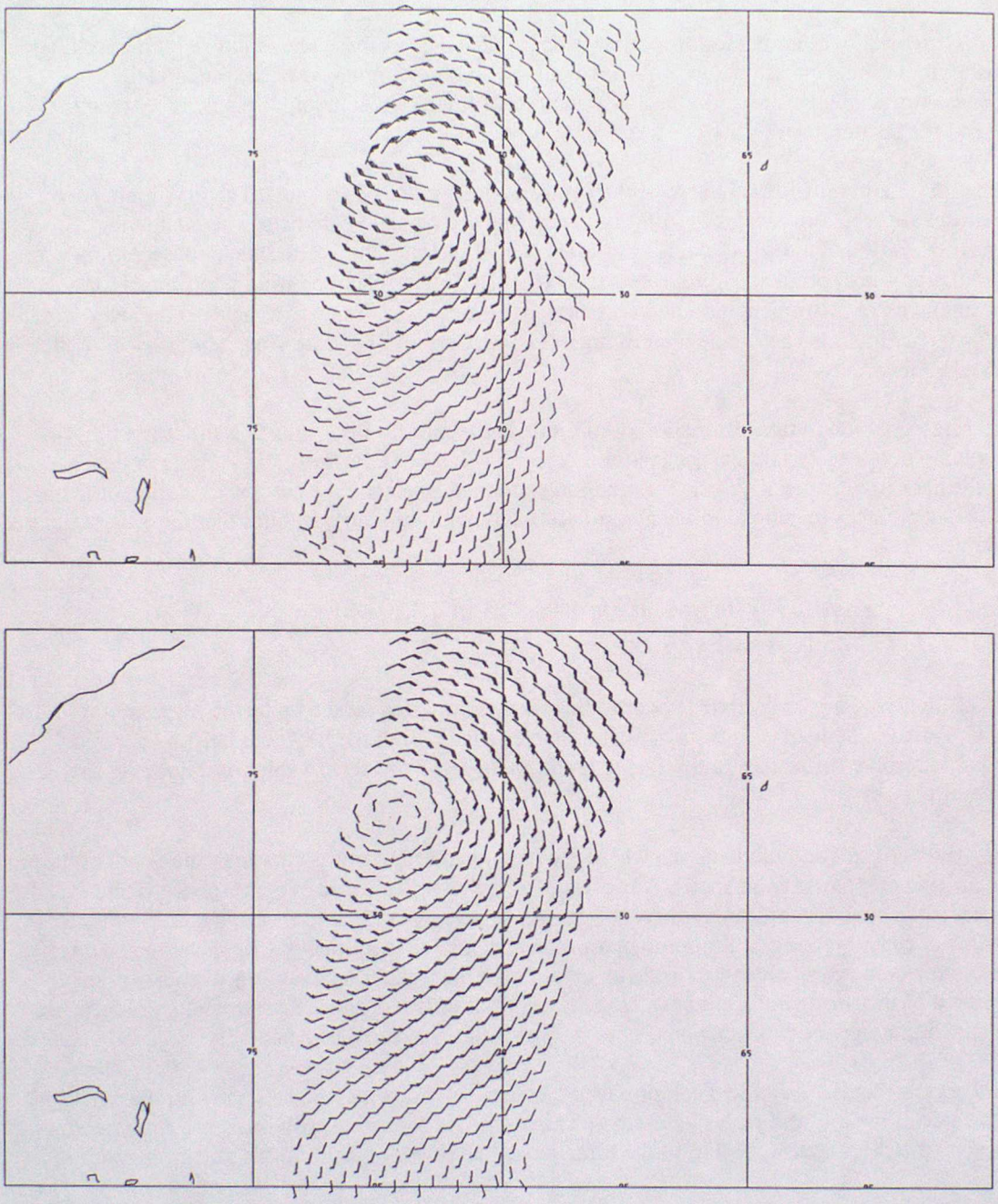
It would appear that the reciprocal solution was preferred as it was more consistent with the winds on the other side of the low and with the forecast. This would be consistent with influence from the first pass of the 'SLICE' processing being in the direction of the satellite track, in this case from north to south.

In this case rejecting observations with an ARC value of less than 80 would have removed a small number of winds near the centre of the circulation and to the North, and a number of winds along the unrealistic line of convergence, which would contribute little, if at all, to the quality of the resulting analysis.

The errors in the positioning of this feature were only 1 or 2 grid points. However the net effect of the current operational scheme was to reinforce, in the analysis, a small forecast error.

Case 1. Pass Over tropical cyclone Emily (15:12 UTC 30 August 1993)

The top diagram shows the ERS-1 scatterometer swath. The lower diagram shows wind values interpolated from the global model analysis to the observation positions.



Key Points and Recommendations

This study suggests that with the current scheme the Ambiguity Removal Confidence has some limited skill in identifying bad data, and it suggests that if a minimum acceptable ARC value is specified this minimum should be below 75.

The impression was gained that data with poor directional quality, on the inner edge of the satellite swath, is on occasion influencing the chosen solution (particularly in areas of light winds) away from this edge.

The current scheme uses two background checks, one when the data is re-processed to derive the UK MO product, and once as part of the current assimilation scheme. The second check may not be redundant, as the author originally thought, in that it removes 'unresolvable' features such as the high winds seen in the centre of tropical cyclones, but consideration should be given to relaxing it so as to avoid reinforcing model errors where consistent Scatterometer data is available.

Significant failures of the ambiguity removal scheme, leading to unrealistic patterns in the swath, are not always identified by any of the current quality parameters, or quality control checks. These failures are rare events, but are generally associated with areas of interest (cyclones, frontal waves, and the detailed position of fronts) which have been poorly forecast. Whilst these unrealistic patterns are easy to identify by eye, it is not practical to inspect the products manually, and the automatic identification of these areas should be considered as part of any future work on Scatterometer processing (unless it is made redundant by advances in variational assimilation techniques).

This study also shows that there is a large amount of meteorological information contained within the current UK MO Scatterometer swathes, which is beyond the resolution of the current global model, which would be of value to higher resolution models in the future.

References

[1] "Wind Retrieval and Ambiguity Removal", EDIPVS Project Note 9, Offiler D.